6G

Review and Evaluation of Statewide-Level Storage Facilities That Could Be Included in CAL-FED Alternatives

Evaluation of Onstream Storage Options Upstream of the Delta

The initial screening of storage options included the 34 reservoir sites shown in Table 6G-1. These sites have been investigated, so information was available to support a preliminary assessment. After the initial screening, 15 remaining options were examined in detail. This appraisal relied on previous studies covering traditional project formulation, engineering feasibility, cost, and environmental aspects. The older studies were supplemented by a cursory reexamination of environmental aspects that reflected the most recent information on critical habitat, wetlands, endangered species, and cultural resources. Because past studies were limited, these environmental reexaminations generated few conclusive findings. The larger reservoirs on major waterways tend to have the most potential environmental consequences. And, there is a definite correlation between the intensity of prior studies and the number of known potential environmental problem issues. The potential environmental issues at the 15 retained options are shown in Table 6G-2.

The appraisal process confirmed that larger projects tend to have the potential to produce less costly and more reliable water supply, but have greater potential impacts on the environment. There is no one accepted method to compare options, particularly those of vastly differing size, but clear conclusions emerged from assessing options within similar groups.

Very Large Onstream Reservoirs (Over 1.0 maf)

With the potential to provide up to 10 maf of additional storage, an enlarged Lake Shasta is in a class apart; at large sizes, it could provide new storage at a favorable unit cost, but with substantial financial and environmental consequences. In the 1.0-2.5 maf range, Auburn Reservoir ranks high, but is burdened with well-publicized environmental controversies. As discussed in Chapter 3, there is an urgent need for greater flood protection on the American River, and a dam at Auburn has been identified by the Reclamation Board as the best flood control alternative. A Thomes-Newville development in the Stony Creek basin remains a possibility, provided it is sized to match its limited water supply; the site also has potential for offstream storage of adjacent basin or Sacramento River water.

The Trinity enlargement option involves a new concept that has not been investigated in detail. The fundamental premise is sound: divert surplus water directly from Lake Shasta to an enlarged Trinity Lake on the Trinity River. This would reap some benefits of enlarging Lake Shasta without the associated major disruptions or relocation costs. The less attractive aspects include a 13-mile tunnel, a 1,500-foot pump lift, and substantial energy costs. This option appears to be more costly than enlarging Lake Shasta, but within the range of consideration. More information on environmental aspects would be needed for a better assessment. Experience has shown large projects at this stage often harbor unexpected environmental drawbacks. Currently, enlarging Trinity Lake is characterized as a future possibility, but not yet thoroughly explored.

TABLE 6G-1

Onstream Storage Options Upstream of the Delta

Stream	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Cache Creek	Wilson Valley	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
	Kennedy Flats	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
	Blue Ridge	Defer	Defer due to environmental impacts and conflicts with federal land management policies.
Stony Creek	Newville (Part of Thomes-Newville Complex)	Retain	
Thomes Creek	Thomes Division (Part of Thomes-Newville Complex)	Retain	
	Paskenta	Defer	Defer in favor of alternate site in same general area.
Elder Creek	Gallatin	Defer	Limited water supply to support significant amount of storage.
Red Bank Creek	Schoenfield (Part of Red Bank Project)	Retain	
S.F. Cottonwood Creek	Dippingvat (Part of Red Bank Project)	Retain	
	Rosewood (Dry Creek)	Defer	Limited water supply to support significant amount of storage.
	Tehama	Retain	
M.F. Cottonwood Creek	Fiddlers	Retain	
Cottonwood Creek	Dutch Gulch	Retain	
N.F. Cottonwood Creek	Hulen	Retain	
Lake Shasta Tributaries	Shasta Enlargement	Retain	
	Enlarged Trinity	Retain	
	Squaw Valley (Squaw Valley Cr.)	Defer	Defer due to high costs and substantial environmental impacts.
	Kosk (Pit River)	Retain	
	Allen Camp (Pit River)	Defer	Primarily a local project, not well suited for statewide supply augmentation.
Little Cow Creek	Bella Vista	Defer	Defer due to high costs and substantial environmental impacts.
South Cow Creek	Millville	Retain	
Inks Creek	Wing	Retain	

TABLE 6G-1

Onstream Storage Options Upstream of the Delta (continued)

Stream	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Deer Creek	Deer Creek Meadows	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
Upper Feather River	Abbey Bridge (Red Clover Creek)	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
	Dixie Refuge (Last Chance Creek)	Defer	Primarily a local project, not well suited for statewide supply augmentation. Also doubtful environmental feasibility.
Yuba River	Marysville/Narrows	Defer	Defer due to high costs and substantial environmental impacts.
M.F. Yuba River	Freemans Crossing	Defer	Limited water supply to support significant amount of storage and doubtful environmental feasibility.
Bear River	Garden Bar	Defer	Primarily a local project.
N.F. American River	Auburn	Retain	
American River	Folsom Enlargement	Retain	
S.F. American River	Coloma/Salmon Falls	Defer	Defer due to environmental and social/third party impacts.
Cosumnes River	Nashville	Retain	
Mokelumne River	Pardee Enlargement	Defer	Primarily a local project.
San Joaquin River	Millerton Enlargement	Retain	

Large Onstream Reservoirs (0.5 to 1.0 maf)

Tehama and Dutch Gulch reservoirs in the Cottonwood Creek Basin clearly warrant further consideration, possibly at smaller sizes than the 0.7 and 0.9 maf considered in the 1983 USACE feasibility study. As an alternative to Dutch Gulch the upstream Fiddlers Reservoir site has promise, but its optimum size may be smaller than 0.5 maf.

Raising Friant Dam on the San Joaquin River by 120 to 140 feet could more than double the current 520 taf capacity of Millerton Lake. While the expansion would be expensive, it is the only San Joaquin Valley surface storage option that appears to offer potential for statewide supply augmentation. Enlarging Friant Dam also would provide flood control benefits.

Kosk Reservoir on the Pit River and Nashville Reservoir on the Cosumnes River appear to offer some promise for storage in this size range, but scant current information is available on their cost, water supply efficacy, or environmental impacts. Reconnaissance reappraisals could fully assess the practicability of these sites. The Nashville site appears to have significant environmental issues associated with its construction.

Coloma Reservoir on the South Fork American River could provide storage within this size range, but any size over 0.2 maf would inundate the town of Coloma and the Marshall Gold Discovery State Historic Park (which would require legislative authorization under Water Code Section 10001.5). Coloma and the nearby Salmon Falls alternative are unpromising and are deferred from further consideration. Marysville and Narrows sites on the Yuba River also are deferred from further consideration because local interests are evaluating a small facility at a nearby site as a local project.

TABLE 6G-2
Retained Onstream Storage Options and Environmental Issues

Reservoir	*Storage[a] Volume (maf)*	*Potential Environmental Issues*
Very Large Reservoirs		
Shasta Enlargement	up to 14.5	stream/river habitat; wild and scenic rivers; trout fisheries; downstream salmon; downstream seepage and erosion impact; deer; numerous listed and candidate species; cultural resources; disruption of established development
Trinity Enlargement	7.2	stream habitat; wetlands/marshes; sensitive plants; eagles; spotted owls; anadromous fish (Trinity and Sacramento Rivers)
Auburn	0.85 - 2.3	stream habitat; wetlands; wildlife; trout; listed amphibian, insect, and plant species; cultural resources; recreation impacts
Thomes-Newville	1.4 - 1.9	deer; stream habitat; cultural resources; possible minor salmon/steelhead runs
Large Reservoirs		
Tehama	0.5 - 0.7	riparian habitat; salmon/steelhead; deer; upland game; bald eagles; cultural resources; various listed species possible
Dutch Gulch	0.7 - 0.9	riparian habitat; salmon/steelhead; deer; upland game; bald eagles; cultural resources; various listed species possible
Kosk	0.8	stream habitat; deer; elk; bear; upland game; eagles; spotted owls; trout; Big Bend Indian Rancheria
Nashville	0.9	wetland/marsh habitat; stream habitat; deer; upland game
Millerton Enlargement	1.0 - 1.4	stream and upland habitat; disruption of established development
Small to Medium Reservoirs		
Wing	0.25 - 0.5	salmon/steelhead (Battle Creek); deer; several listed bird, amphibian, insect, plant species
Red Bank Project	0.35	stream habitat; California red-legged frog; spring-run salmon
Millville	0.1 - 0.25	stream habitat; salmon
Hulen	0.2 - 0.3	fossils; stream habitat
Folsom Enlargement	1.3	stream and upland habitat; eagles; several listed plant species; cultural resources; disruption of established development
Fiddlers	0.2 - 0.5	stream habitat

[a] Volume shown is total storage volume, including, where applicable, the existing storage capacity of reservoirs to be enlarged.

Small-to-Medium-Sized Onstream Reservoirs (0.1 to 0.5 maf)

Options within this range selected for analysis included three sites on upper Sacramento Valley tributaries that appear to offer acceptable combinations of water supply capability, cost, and environmental compatibility. The largest of these, Wing Reservoir on Inks Creek with a diversion from Battle Creek, could provide over 0.4 maf of storage. The other apparently viable options, both near the lower limit of this size range, are the Red Bank Project on South Fork Cottonwood and Red Bank Creeks, and Millville Reservoir on South Cow Creek. One of the two on-stream reservoirs developed by the Red Bank Project would be used primarily as an offstream storage facility. Hulen Reservoir on North Fork Cottonwood Creek would be high on the list except it would inundate a premier deposit of Cretaceous fossils. (Medium-sized projects involving Cottonwood Creek water, such as the Fiddlers site, are alternatives, not adjuncts, to the larger downstream Tehama and Dutch Gulch storage sites.)

Enlargement of Folsom Lake was among the options considered to provide additional flood control along the lower American River. If that enlargement were practicable, it could provide a valuable increment of water supply storage (depending on the flood oper-

ating criteria). That storage would be expensive, so it is unlikely except as an element of a comprehensive flood control package.

The remaining two medium-sized options are Bella Vista Reservoir on Little Cow Creek near Redding and Squaw Valley Reservoir on Squaw Valley Creek near McCloud. These projects appear more expensive and more environmentally disruptive than the competing options. Therefore, they are not considered promising prospects for future development and are deferred from further evaluation.

Evaluation of Offstream Storage Options Upstream of the Delta

The initial screening of upstream of Delta offstream storage options included the 14 proposals in Table 6G-3. The initial screening indicated that eight of those warranted further examination, including a review of past studies and a cursory reexamination of the latest available environmental information. The potential environmental issues identified with the retained options are shown in Table 6G-4. Offstream storage has an inherent environmental advantage because the reservoirs tend to be on minor tributaries, which reduces impacts on live streams and riparian habitat. For most of the larger offstream options, that advantage must be balanced against the potentially severe environmental impacts with diversions from major nearby streams. Evaluating the retained options from that perspective leads to the following general conclusions.

Very Large Offstream Reservoirs (Over 1.0 maf)

Two of the five very large reservoir options have the potential to provide more than 4 maf of new storage, but not without some considerable environmental effects. The existing 1.6 maf Lake Berryessa could be enlarged to provide massive amounts of storage for surplus flows pumped from the lower reaches of the Sacramento River. Past studies have shown the unit cost of storage in the large project sizes would be attractive, though a 31-mile conveyance facility with a 700-foot pump lift would be required. The financial and energy costs of this conveyance would be enormous, as would the environmental consequences. Diversion of around 12,000 cfs from the lower river could prove challenging. Under current conditions, offstream storage of Sacramento River water in an enlarged Lake Berryessa does not appear to hold much promise in the foreseeable future.

TABLE 6G-3

Offstream Storage Options Upstream of the Delta

Watershed	*Reservoir*	*Retain or Defer*	*Reason for Deferral*
Putah Creek	Berryessa Enlargement	Retain	
Various	Sites	Retain	
Various	Colusa	Retain	
Stony Creek	Thomes-Newville	Retain	
Stony Creek	Glenn	Retain	
S.F. Cottonwood Creek	Red Bank Project	Retain	
Inks Creek	Tuscan Buttes	Defer	Defer due to substantial environmental impacts.
Bear River	Waldo	Defer	Being actively pursued by Yuba County Water Agency; not considered for statewide supply.
Deer Creek	County Line	Defer	Defer in favor of alternate site in same general area.
Deer Creek	Deer Creek	Retain	
Laguna Creek	Clay Station	Retain	
Calaveras River	Duck Creek	Defer	Defer due to extraordinarily high costs.
Calaveras River	South Gulch	Defer	Primarily a local project, not well suited for statewide supply augmentation.
Littlejohns Creek	Farmington Enlargement	Defer	Primarily a local project, not well suited for statewide supply augmentation.

TABLE 6G-4
Retained Offstream Storage Options and Environmental Issues

Reservoir	*Storage Volume (maf)*	*Potential Environmental Issues*
Very Large Reservoirs		
Berryessa Enlargement	up to 11.5 additional	stream habitat; wetlands; deer and upland game; Putah Creek trout fishery; Sacramento River anadromous fish; listed/sensitive plant species; cultural resources; disruption of established agriculture and recreation; population displacement
Thomes-Newville	1.4 -1.9	deer; stream habitat; cultural resources; possible minor salmon/ steelhead runs
Glenn	6.7 - 8.7	stream habitat; wetlands/vernal pools; deer and upland game; deer winter range; Sacramento River anadromous fish; eagles; cultural resources; population displacement
Sites	1.2 - 1.8	Sacramento River anadromous fish
Colusa	3.0	Sacramento River anadromous fish
Large Reservoirs		
Deer Creek	0.6	vernal pools; meadow/marsh habitat; listed bird, invertebrate, insect, and plant species; cultural resources
Small to Medium Reservoirs		
Red Bank	0.35	stream habitat; California red-legged frog; spring-run salmon
Clay Station	0.2	stream habitat; wetlands; meadow/marsh habitat; listed bird, invertebrate, insect, and plant species

Similarly, a Glenn Reservoir, a combination of Thomes-Newville Reservoir on the North Fork Stony Creek and Rancheria Reservoir on the mainstem of Stony Creek would provide over 8 maf of storage for surplus water of the upper Sacramento River. The two-compartment Glenn Reservoir was conceived as terminal storage for exports from the North Coast rivers. Following passage of the Wild and Scenic Rivers Act of 1972, it was reformulated for offstream storage of water diverted from the Sacramento River. The unit cost of storage appeared reasonable, but controversy over diversions to the Tehama-Colusa Canal cast doubt on the environmental feasibility of diverting large flows to support the large-scale Glenn Reservoir. At this time, a large Glenn Reservoir does not appear to be a likely candidate for early construction. The smaller Thomes-Newville Reservoir (1.4 to 1.9 maf) operated as an offstream storage reservoir remains a possibility.

The other very large offstream storage options, Sites and Colusa Reservoirs, are related, in that the 3 maf Colusa Reservoir represents a northward expansion of the 1.2 to 1.8 maf Sites Reservoir into the Hunter and Logan Creek Basins. Either version of the reservoir would involve minimal environmental impacts within the area of inundation. The drawback is diverting surplus water from the Sacramento River for storage. Past proposals have focused on off-season use of the existing Tehama-Colusa Canal diversion facilities at Red Bluff Diversion Dam and the Glenn-Colusa Irrigation District pumping plant near Hamilton City. Alternative Sites/Colusa conveyance facilities are now being examined. Although the alternative conveyance facilities would likely raise costs, the Sites and Colusa offstream storage options remain the most promising.

Large Offstream Reservoirs (0.5 to 1.0 maf)

Deer Creek Reservoir in northeastern Sacramento County is the only upstream of Delta offstream storage option within this size range. Past investigators have examined a 0.6 maf Deer Creek Reservoir to store surplus water from the American River, delivered from an enlargement of the existing northern reaches of the Folsom South Canal. Another version of the project was considered for flood control, incorporating a gravity diversion direct from Folsom Lake via a new outlet at Mormon Island Dike. Major offstream storage in the Deer Creek area would be ideally suited to develop some of the abundant surplus flow of the American

River without the difficulties associated with Auburn Dam. Also, by diverting directly from Folsom Lake or Lake Natoma, this project would avoid the principal conflicts with anadromous fish. Initial studies indicate a Deer Creek offstream storage project would be expensive—with a unit storage cost several times that of the lower-cost options.

Small to Medium Offstream Reservoirs (0.1 to 0.5 maf)

Two options fall into this range, the Red Bank Project and Clay Station Reservoir. The Red Bank Project would consist of a 100 taf Dippingvat Reservoir and a 250 taf Schoenfield Reservoir. Dippingvat Reservoir would store water from the South Fork of Cottonwood Creek. Water would be diverted from Dippingvat to Schoenfield Reservoir where it would later be released down Red Bank Creek to the Sacramento River. Water could also be released via a new conveyance facility to the Corning Canal or the Tehama-Colusa Canal.

The Clay Station Reservoir is a smaller version of Deer Creek Reservoir, but 8 miles south. Its storage cost would be similar to Deer Creek's (very high). With its small size and high cost, Clay Station Reservoir offers little promise as a statewide water supply option.

Likely Storage Options Upstream of the Delta

Figure 6G-1 shows the location of likely surface storage options upstream of the Delta. This reappraisal of surface reservoir options identified several that appear to offer the best prospects. Foremost in this group, in order of size, are:

- Colusa Reservoir, 3.0 maf offstream
- Thomes-Newville Reservoir, 1.4 to 1.9 maf offstream
- Sites Reservoir, 1.2 to 1.8 maf offstream
- Dutch Gulch Reservoir, 0.7 to 0.9 maf onstream (or its upstream alternative, Fiddlers Reservoir, 0.2 to 0.5 maf)
- Tehama Reservoir, 0.5 to 0.7 maf onstream
- Wing Reservoir, 0.25 to 0.5 maf onstream (with Battle Creek diversion)
- Red Bank Project, 0.35 maf onstream and offstream
- Millville Reservoir, 0.1 to 0.25 maf onstream

A second tier of options offers substantial water supply potential, but with greater environmental impacts and/or economic costs that create some uncertainty about their implementability. From a flood control standpoint, enlarged Shasta, Auburn, and enlarged Millerton would provide important benefits. In order of size, these sites are:

- Enlarged Lake Berryessa, up to 11.5 maf additional offstream
- Enlarged Lake Shasta, up to 10 maf additional onstream
- Glenn Reservoir, 6.7 to 8.7 maf offstream
- Auburn Reservoir, 0.85 to 2.3 maf onstream
- Thomes-Newville Reservoir, 1.4 to 1.9 maf onstream
- Enlarged Millerton Lake, 0.5 to 0.9 maf additional onstream
- Enlarged Folsom Lake, 0.37 maf additional onstream

A third group of options includes one that may be a viable alternative, but for which limited information is available. This site might be characterized as "worthy of a second look" in the future:

- Kosk Reservoir, 0.8 maf onstream

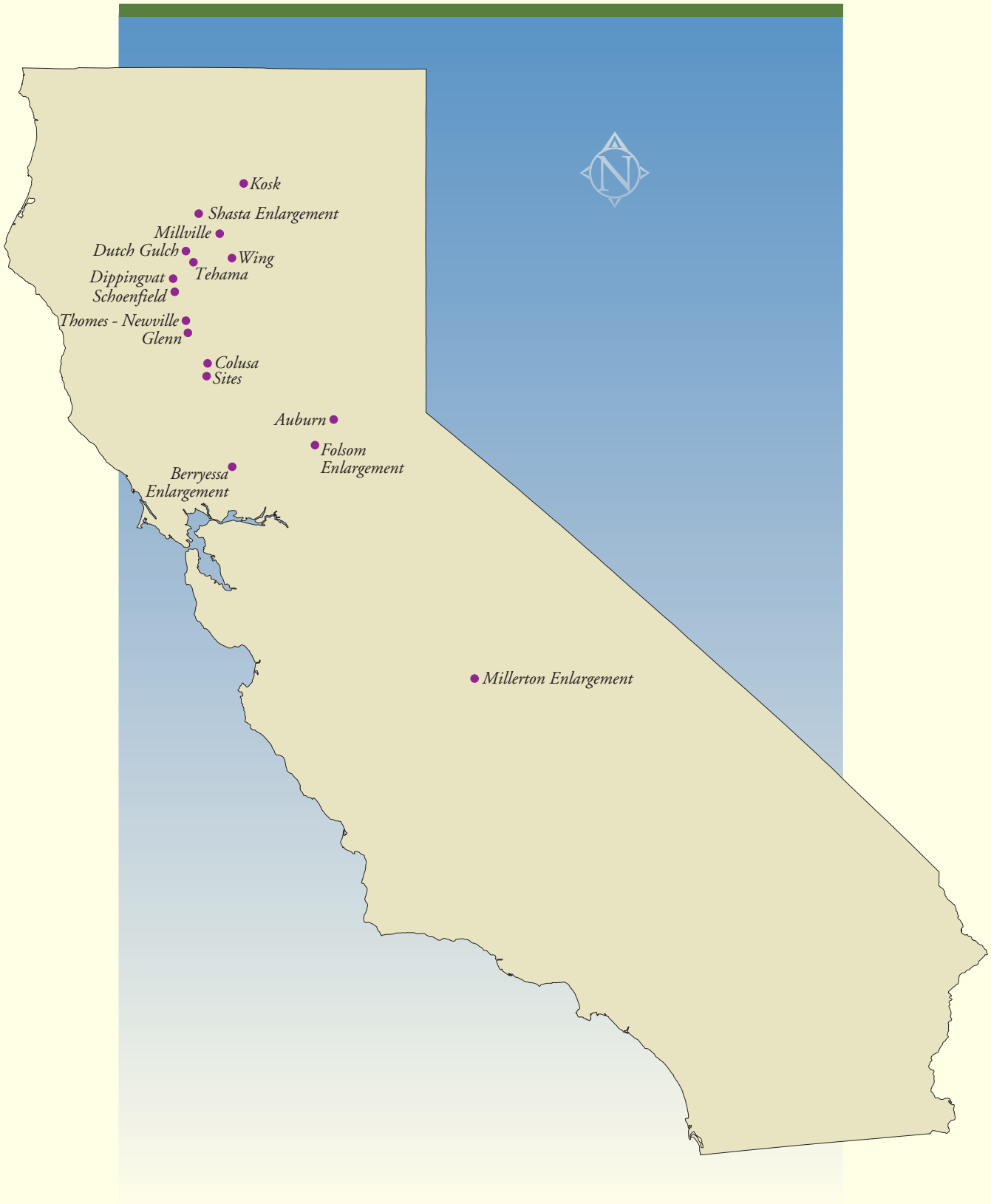
Operation of Storage Upstream of the Delta

Additional surface storage upstream of the Delta would be effective if operated with major water supply reservoirs in the basin, principally Shasta, Oroville, and Folsom. Under California's water rights hierarchy, new facilities may store surplus water that is not needed to meet preexisting rights. Since virtually no surplus water is available during the irrigation season, storage in new projects will be limited to late fall, winter, and early spring. Most storable flow occurs during periods of flood runoff. But, under certain conditions, coordinated operation with other reservoirs may allow occasional storage of fall releases made to achieve mandatory flood reservations.

A Sites Reservoir offstream storage facility provides a good example of how a Sacramento Valley surface project could be operated in coordination with other facilities. A large Sites Reservoir would provide 1.8 maf of storage in the foothills west of Maxwell. The large Sites Reservoir would be formed by constructing two main dams on Stone Corral and Funks Creeks and several smaller saddle dams along the low divide be-

FIGURE 6G-1

Likely Reservoir Sites Upstream of the Delta



tween Funks and Hunters Creeks. A larger Colusa Reservoir, providing 3.0 maf of storage, would be formed by extending the large Sites Reservoir north into the Hunters and Logan Creek drainages.

In this configuration, water would be delivered to the reservoirs by winter use of the existing Tehama-Colusa Canal (which diverts from the river near Red Bluff), and by diversion to the Glenn-Colusa Canal at its pumping site near Hamilton City. A new pumped intertie would deliver Glenn-Colusa Canal water to the Tehama-Colusa Canal, from which it would be lifted a maximum of about 320 feet to Sites/Colusa Reservoirs. In a recently conceived alternative, use of the existing diversions would give way in favor of a single pumping facility south of Chico Landing.

Most of the water available for storage in Sites/Colusa Reservoirs occurs from December through April. Whenever water and energy were available, operators would make maximum effort to fill Sites/Colusa Reservoirs. As seasonal water demands increased, water would be withdrawn from system reservoirs to meet needs. Since water would have to be pumped to Sites/Colusa Reservoirs, the optimum operation would favor making the initial withdrawals from onstream reservoirs with higher ratios of inflow to storage (which are more likely to refill in the subsequent wet season). At some point, depending on the dryness of the year and the storage status of other facilities, withdrawals would be made from Sites/Colusa Reservoirs. To minimize potential impacts of the existing diversions on the Sacramento River fisheries, Sites/Colusa Reservoirs would release water back into the two canals in exchange for reduced diversions from the river. Sites/Colusa Reservoirs would be drawn to minimum pool only in a prolonged series of drought years. In wetter periods, they would operate within a narrow range near full.

Evaluation of Off-Aqueduct Storage Options South of the Delta

In the Department's recent alternative South of Delta offstream reservoir reconnaissance study, all geographically possible off-aqueduct reservoir sites on the west side of the San Joaquin Valley were identified. Alternatives on the east side of the valley were not considered due to the excessive cost of conveyance connections to the California Aqueduct. Ninety-seven dam sites in 46 watersheds were evaluated (Table 6G-5) for their potential to economically improve SWP water supply reliability with minimal environmental and social impacts. For each potential reservoir site, the capital cost and the potential environmental impacts were evaluated and rated at a general level to determine the sites that should be studied in more detail.

The Department's study examined a wide range of storage volumes to evaluate potentially feasible projects based on the future long-term availability of exports from the Delta and the level of SWP contractor participation. Multiple reservoir sizes were considered for each alternative dam site. Volumes from 0.1 to 2 maf of storage were classified into four categories (Table 6G-6).

All sites were evaluated using the same level of detail for each of the screening criteria. To evaluate and compare engineering characteristics, site information was gathered and construction costs were estimated for each alternative. For this purpose, a basic design configuration was selected. The storage capacity and water surface area of each reservoir option were calculated. The embankment volumes of each main dam and associated saddle dams were calculated.

The capital costs of all reservoir options were based on previous cost estimates developed for LBG facilities. Sixteen categories of cost, including mitigation costs, were calculated. A rating of the alternatives was performed based on estimated capital costs per acre-foot of storage. A unit storage cost of above $3,000/af was deemed impractical and was used as a threshold for deferring alternative sites. After deferring alternatives with unit storage costs above the practical threshold, 34 dam sites in 18 watersheds were retained for further consideration. The unit storage cost for each of these options was translated to a 100 point system, with 0 points assigned to a unit cost of $3,000/af of storage and 100 points to a unit cost of $0/af of storage. Unit costs and scores were developed for several reservoir sizes at each site to cover the potential range of storage volume available at each dam site. The unit costs and scores for the reservoir sizes evaluated at each dam site were plotted versus volume. Curves were drawn through the points associated with each dam site to allow interpolation of this information for the entire range of storage volumes available at each dam site.

Environmental criteria were developed by the Department and DFG. Factors affecting the degree of environmental sensitivity of each alternative reservoir site were identified by the Department and DFG, and were reviewed by USFWS. Six environmental screen-

TABLE 6G-5
Watersheds Identified for South of the Delta Storage Options

Watershed	*County*	*Watershed*	*County*
Arroyo Ciervo	Fresno	Los Banos Creek	Merced
Arroyo Hondo	Fresno	Los Gatos Creek	Fresno
Bitter Creek	Kern	Los Vaqueros	Contra Costa
Bitterwater Valley	Kern/San Luis Obispo	McKittrick Valley	Kern
Broad Creek	Kern	Moreno Gulch	Fresno
Buena Vista Creek	Kern	Mustang Creek	Merced
Buena Vista Lake Bed	Kern	Orestimba Creek	Stanislaus
Cantua Creek	Fresno	Ortigalita Creek	Merced
Capita Canyon	Fresno	Oso Creek	Stanislaus
Castac Valley	Kern/Los Angeles	Packwood Creek	Kern
Deep Gulch	San Joaquin	Panoche Hills	Fresno
Del Puerto Canyon	Stanislaus	Panoche/Silver Creek	Fresno/San Benito
Garzas Creek	Stanislaus	Pleito Creek	Kern
Hospital Creek	San Joaquin/Stanislaus	Quinto Creek	Merced/Stanislaus
Ingram Canyon	Stanislaus	Romero Creek	Merced
Ingram/Kern Canyon	Stanislaus	Salado Creek	Merced
Kellogg/Marsh Creek	Contra Costa	Salt Creek	Fresno/Kern/Merced
Kern Canyon	Stanislaus	San Emigdio Creek	Kern
Kettleman Plain	Kings	San Luis Creek	Merced
Laguna Seca Creek	Merced	Sandy Creek	Kern
Little Panoche Creek	Fresno	Santiago Creek	Kern
Little Salado/Crow Creek	Stanislaus	Sunflower	Kings/Kern
Lone Tree Creek	San Joaquin	Wildcat Canyon	Merced/Fresno

ing criteria were developed. The environmental resources information varied among the sites. To ensure that all the options were evaluated equally, all sites used the same level of detail for each of the screening criteria. In evaluating wetland resources, USFWS National Wetland Inventory Maps were used to determine wetland abundance and types at each site. USGS national aerial photographic project maps were used to determine vegetation community abundance and type, and to obtain additional habitat and land use information. Listed and candidate animal and plant species that could potentially be found at the alternative sites were identified by searching the 1995 DFG Natural Diversity Data Base, the fifth edition of the California Native Plant Society's inventory of rare and endangered vascular plants of California, and DFG Wildlife Habitat Relationships System publications.

Economic and environmental sensitivity scores were given equal weight and combined to develop a score for each alternative reservoir site ranging from 0 to 100 points. Table 6G-7 shows the combined ranking of each alternative reservoir site, sorted by the four storage volume categories. Alternative reservoir sites with the highest scores were selected for each storage volume category. A minimum of 4 and a maximum of 10 alternative reservoir sites were chosen for each size category to provide a reasonable variety of alternatives for further evaluation. Using the previously defined categories, alternative reservoir sites were selected for further evaluation. Many of the alternative reservoir sites were selected in more than one size category. As shown in Table 6G-8, a total of 19 reservoir sites in 10 watersheds were retained for more analysis after the initial evaluation. These sites are shown in Figure 6G-2.

Likely Off-Aqueduct Storage Options South of the Delta

After a general evaluation, five sites appeared most favorable: Garzas Creek, Ingram Canyon, Los Banos

TABLE 6G-6
South of the Delta Off-Aqueduct Storage Size Categories

Category	*Storage (maf)*
Small	0.1 - 0.25
Medium	0.25 - 0.5
Large	0.5 - 1.0
Very Large	1.0 - 2.0

TABLE 6G-7

Ranking of Off-Aqueduct Storage Options South of the Delta

Dam Site	*Potential Range of Storage (taf)*	*Unit Cost ($/af)*	*Cost Ranking (0-100)*	*Environmental Sensitivity Ranking (0-100)*	*Combined Ranking (0-100)*
Very Large Reservoirs (1.0 to 2.0 maf)					
LBG/Los Banos Creek (Dam 181)	1,000-2,000	730-550	76-82	31-31	53-56
Garzas Creek (Dam 104)	1,000-1,750	1,600-1,310	47-56	53-52	50-54
Panoche/Silver Creek (Dam 114)	1,000-2,000	1,370-1,210	54-60	47-45	51-52
Orestimba Creek (Dam 171)	1,000-1,140	1,670-1,600	44-47	46-46	45-46
Large Reservoirs (0.5 to 1.0 maf)					
LBG/Los Banos Creek (Dam 181)	500-1,000	1,000-730	67-76	33-31	50-53
Panoche/Silver Creek (Dam 112)	500-1,000	1,620-1,320	46-56	49-47	48-52
Panoche/Silver Creek (Dam 114)	500-1,000	1,830-1,370	39-54	48-47	44-51
Ingram Canyon (Dam 37)	500-980	1,950-1,400	35-53	48-48	42-51
Orestimba Creek (Dam 170)	500-900	1,890-1,410	37-53	49-46	43-50
Garzas Creek (Dam 104)	500-1,000	2,090-1,600	30-47	54-53	42-50
Garzas Creek (Dam 105)	500-630	1,910-1,660	36-45	54-54	45-49
Panoche/Silver Creek (Dam 45)	500-990	2,300-1,920	23-36	59-57	41-47
Garzas Creek (Dam 109)	500-940	2,250-1,730	25-42	54-52	40-47
Orestimba Creek (Dam 171)	500-1,000	1,930-1,670	36-44	48-46	42-45
Medium Reservoirs (0.25 to 0.5 maf)					
LBG/Los Banos Creek (Dam 181)	250-500	1,660-1,000	45-67	35-33	40-50
Panoche/Silver Creek (Dam 112)	250-500	2,250-1,620	25-46	49-49	37-48
Sunflower Valley (Dam 177)	250-500	2,490-1,460	17-51	46-44	31-48
Garzas Creek (Dam 106)	250-310	2,050-1,820	32-39	54-54	43-47
Garzas Creek (Dam 105)	290-500	2,400-1,910	20-36	54-54	37-45
Panoche/Silver Creek (Dam 114)	250-500	2,050-1,830	32-39	49-48	40-44
Orestimba Creek (Dam 170)	250-500	2,630-1,890	12-37	50-49	31-43
Garzas Creek (Dam 104)	250-500	2,950-2,090	2-30	55-54	28-42
Orestimba Creek (Dam 171)	250-500	3,000-1,930	0-36	49-48	24-42
Ingram Canyon (Dam 37)	250-500	3,120-1,950	N/A-35	49-48	N/A-42
Small Reservoirs (0.10 to 0.25 maf)					
Kettleman Plain (Dam 99)	100-250	2,990-1,620	0-46	61-59	30-53
Garzas Creek (Dam 106)	100-250	3,300-2,050	N/A-32	56-54	N/A-43
Garzas Creek (Dam 107)	100-250	3,300-2,020	N/A-33	56-54	N/A-43
Panoche/Silver Creek (Dam 111)	100-240	3,480-2,020	N/A-33	51-49	N/A-41
LBG/Los Banos Creek (Dam 181)	100-250	3,350-1,660	N/A-45	37-35	N/A-40
Panoche/Silver Creek (Dam 114)	100-250	3,560-2,050	N/A-32	51-49	N/A-40
Little Salado/Crow Creek (Dam 63)	100-130	2,810-2,310	6-23	49-48	28-36
Quinto Creek (Dam 54)	110-250	3,120-2,370	N/A-21	50-49	N/A-35
Romero Creek (Dam 56)	100-180	3,410-2,560	N/A-15	53-53	N/A-34
Garzas Creek (Dam 108)	100-250	4,010-2,870	N/A-4	56-55	N/A-30

Creek, Orestimba Creek, and Panoche/Silver Creek. As all past studies have shown, Los Banos Creek is the most cost-effective reservoir option considered for size categories above 250 taf. The next least costly reservoir option ranges from about 50 percent more expensive for the medium size category up to about 100 percent more expensive for the very large category. In the environmental analysis, however, the Los Banos Creek option received the lowest environmental sensitivity rating (or had the most potential impacts) of all alternative sites. This could be because there is a greater level of knowledge about this reservoir site. Los Banos Creek was the highest ranked reservoir option based on total combined rating for reservoir sizes above 250 taf.

A reservoir at Little Salado-Crow Creek would have a high surface area to storage volume ratio. There would be high evaporation losses, making the site unfavorable. Sunflower Reservoir site lies 10 miles west of the California Aqueduct and would require an extended conveyance system. Significant seepage rates would also be expected at this site. These two sites (in addition to Romero Creek, Kettleman Plain, and Quinto Creek) have small storage capacities. Preliminary modeling results indicate that the range of additional surface storage south of the Delta should be around 500 to 2,000 taf. The cumulative environmental impacts of several small to medium reservoirs needed to attain the storage capacity would probably be greater than one larger reservoir. Therefore, the small to medium size reservoir options were deferred.

Enlarging San Luis Reservoir has been considered for additional storage, but because of engineering and economic criteria, this has been deferred. The integrity of an enlarged San Luis Dam has been questioned, and the cost would be high.

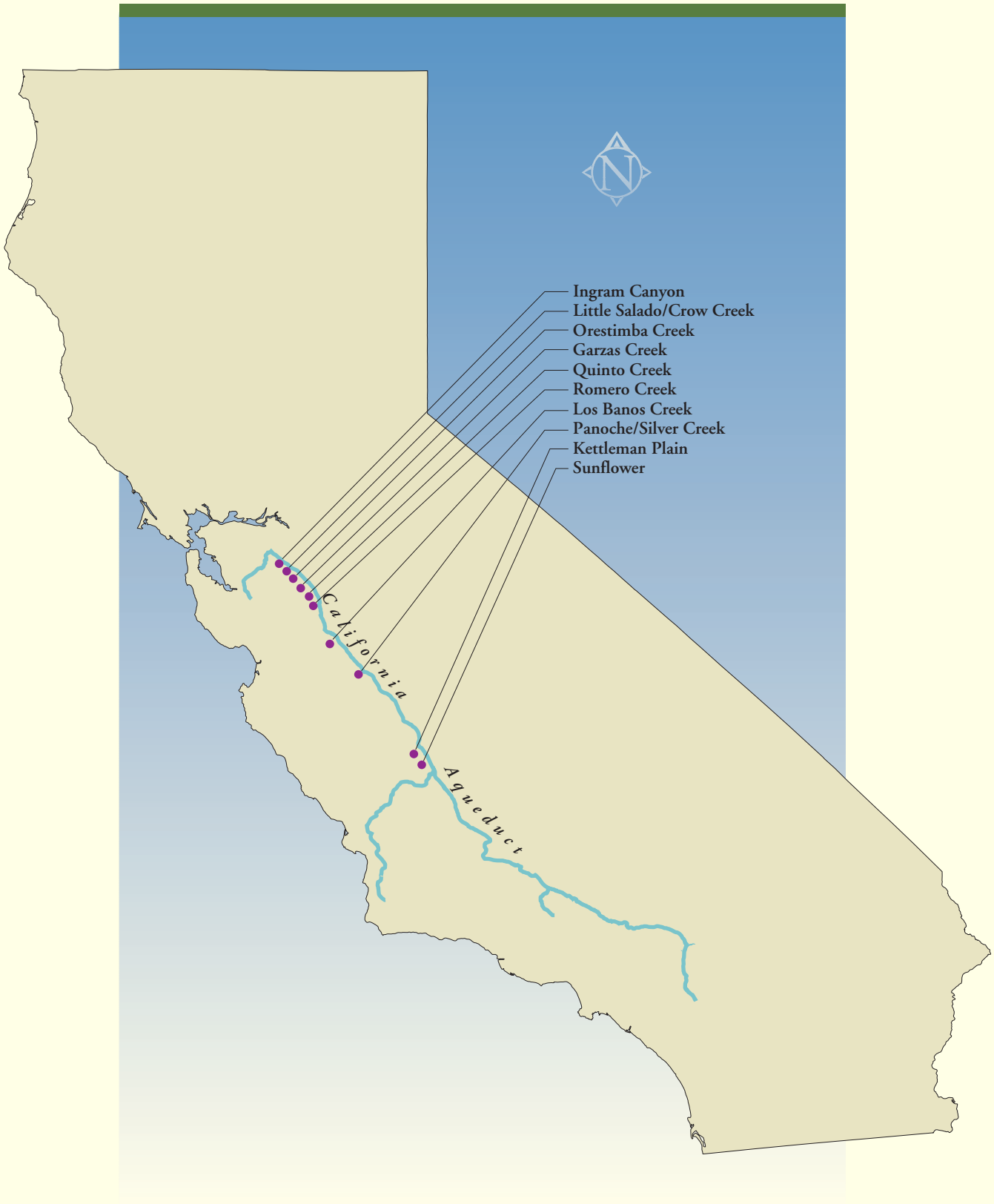
TABLE 6G-8

Retained Off-Aqueduct Storage Options South of the Delta

Watershed	*Dam Site*	*Reservoir Size Category*			
		Small	*Medium*	*Large*	*Very Large*
Garzas Creek	104		X	X	X
	105		X	X	
	106	X	X		
	107	X			
	108	X			
	109			X	
Ingram Canyon	37		X	X	
Kettleman Plain	99	X			
LBG/Los Banos Creek	181	X	X	X	X
Little Salado/Crow Creek	63	X			
Orestimba	170		X	X	
	171		X	X	X
Panoche/Silver Creek	111	X			
	112		X	X	
	114	X	X	X	X
	45			X	
Quinto Creek	54	X			
Romero Creek	56	X			
Sunflower	177		X		

FIGURE 6G-2.

Off-Aqueduct South of the Delta Watershed Sites



Operation of Off-Aqueduct Storage South of the Delta

To illustrate how south of Delta offstream storage would operate, LBG Reservoir is used as a model. This example treats LBG as an SWP facility. To meet CVP service area needs, USBR could participate with the Department in this project.

LBG would be located on Los Banos Creek 6 miles west of the California Aqueduct in the Los Banos Valley area. The main damsite would be about 80 miles south of the Delta. Facilities would consist of a storage reservoir with associated pump-generating plants and conveyance channels. Delta winter flows would be conveyed through the California Aqueduct and pumped into LBG for storage. Operation of the reservoir would be similar to that of San Luis Reservoir, except that LBG would retain about one half to two-thirds of its storage in average years to improve drought year water supply reliability of the SWP.

During periods of low Delta inflow, LBG would provide water supplies south of the Delta to reduce the demand for Delta exports. Added flexibility could permit the SWP to take advantage of seasonal and short-term water quality improvements to enhance the quality of delivered supplies. The 1.73 maf LBG Reservoir examined in the 1990 feasibility study would operate through a range of about 550 to 750 taf each year, filling in the early spring and releasing water to the California Aqueduct between May and September.